Evolutionary Approaches to Historical Demography and Agent-Based Modelling

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"[D]emography is neither theoretical physics nor is it mineralogical chemistry": with this truism, Charbit (2009: 48) highlighted what he thinks is particular for the human sciences: explanations should be based on factors that are peculiar to a given historical context. Indeed, doing historical demography is not about finding eternal "laws" but rather about carefully documenting and analysing population patterns and demographic change in particular historical contexts. It might therefore be tempting to follow Charbit in dismissing altogether the ambition for general population theory and to stick with idiosyncratic narratives.

Although historical peculiarities do and should play a role, historical demography should not give up the ambition to develop and test general theories. After all, why would Charbit's argument hold for demography and not for a field like biology? Aren't populations of plants and animals just as peculiar for their historical environment as human populations? It is precisely the uniqueness of every organism that is highlighted in the populationist biology inherited from Charles Darwin. Darwinian evolutionary theory can be considered superior to the earlier theories because it is able to account for the changing biological diversity and developments that occurred not only before and but also after the formulation of the theory.

It would be fruifull to intensify the conversation between historical demography and evolutionary theory. "Human culture and biology jointly and collaboratively drive the evolution of human demography" (Levitis 2015: 415). Recognizing that birth, marriage, migration, and death have both biological and cultural significance, demographic approaches to evolution and evolutionary approaches to demography may integrate important aspects of cultural and biological evolution. Evolutionary demography may cross barriers between social scientific and biological approaches to population processes (Sear 2015; Levitis 2015).

To aid the development of evolutionary approaches in historical demography, Agent-Based Modelling (ABM) represents a promising method. ABM simulates how populations of agents evolve over time based on theoretically assumed rules of action and interaction between agents and with the environment (Grow and Van Bavel 2015). It is a particularly useful addition to the toolkit of historical demographers because, first, in contrast to other approaches to micro-simulation, it is strongly theory-oriented, second, it offers a way to handle fundamental data gaps, and, third, it is fundamentally oriented towards heterogeneity and change, which is in line with evolutionary theoretical approaches.

In historical demography, data are often available on some aggregate level while a lot of information about the underlying micro-level processes is lacking; individuals involved can no longer be asked questions. ABM may then be used as a way to simulate how the process may have worked on the individual level, and calculate whether the theoretical micro-mechanisms can indeed explain what is observed on the macro level. This approach consist roughly of the following three steps: 1) document target facts A and B, for example correlational patterns; 2) hypothesize what are theoretically the mechanisms that may link the observed patterns A and B; 3) simulate the theoretical mechanisms and quantify their implications to see which of them could indeed explain how A is connected to B.

An evolutionary approach to historical demography implies that human populations are studied as complex adaptive systems. ABM has a range of characteristics that makes the approach particularly well suited to study such systems: the focus on dynamics and processes, the scalability and flexibility, the feasibility to model adaptive rather than optimizing agents, and the enhanced ability to address the role played by heterogeneity and variation (Miller and Page 2007).

ABMs are inherently *dynamic*: even if one can take snapshots of the system's situation at discrete points in time, the results of the model inherently change over time and the focus is drawn to the process at least as much as to the state. Like evolutionary theory, ABMs are inherently *process oriented*: the focus is on understanding the mechanisms of change. Evolutionary demography should also be able to integrate insights gained at different scales of observation and from diverging scholarly disciplines. The *scalability* of ABMs and the *flexibility* of specifying agent behaviour and interactions are particularly useful here. The scalability refers to the ability of ABM to explore a system's behaviour both with a very low and a very high number of agents and to switch the focus from micro- to macro-level system properties. The flexibility refers to the fact that ABMs can capture a very wide class of behaviours, which is particularly useful for implementing insights from different study disciplines: agents may respond to the constraints imposed by the human metabolic system as well as to the cultural rules implied by human society. Both kinds of rules can be specified in the same ABM. A model may implement mechanisms involved in multiple inheritance models, involving genetic, ecological, and cultural inheritance, and change across generations can be simulated over thousands of generations. Snapshots can be taken at each point in time, enabling comparison with real life data employing standard statistical tools.

Given the dynamic nature and flexibility of ABMs, agents can be designed to be *adaptive*, i.e., as learning from previous experiences within and across generations. This allows moving away from unrealistic models of well-informed agents who rationally processes all the relevant information to optimize behaviour to maximize utility. Agents may learn, build networks, and inherit knowledge and resources from previous generations. Such approach is consistent with evolutionary theory as well as with basic insights from psychology and sociology.

Finally, ABM facilitates to focus on *heterogeneity*. While the focus of statistical regression analysis is on how averages depend on a set of variables, this may be insufficient to do justice to the role played by diversity and variation in explaining population patterns and change. Enhancing the ability to address the role played by heterogeneity seems important for improving population theory. In applications of ABM, it has become clear that a given outcome may be produced by different pathways or that a given pathway may lead to very different outcome, depending on the size and composition of the population.

ABM has proven to be able to yield both results exemplifying convergent as well as divergent evolution. This matches very well with the observation that, while the transition from moderately high to low mortality and fertility is a very general phenomenon, uniform explanations in terms of macro-level processes such as industrialisation, urbanisation, and modernisation have failed the empirical tests to a large extent: the decline of fertility got started under widely different economic conditions, or failed to kick off when theory would have predicted this. Theories such as those developed by Frank Notestein spoke about interactions between the economy and populations largely at the macro-level, without accounting for the heterogeneity within economies and populations. This approach failed to pay due attention to the role played by variation and heterogeneity. Thanks to more detailed research in historical demography, often looking at very specific local communities and populations, it became clear that fertility and mortality decline can take place under widely differing conditions. In-depth study of local populations helped to understand more about the role played by distinctive environmental and cultural constraints, implying that there is not one universal transition pathway. The continuing diversity observed in demographic phenomena like "the" demographic transition, highlights that it will be key for demographic theory to understand the mechanisms that continue to renew population heterogeneity.

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